Effect of foliar fertilization on the growth of some potato varieties[1]

Mohammed Yousif Merhej[*] Ali Hussein Jassim[**]
[*,**]Agriculture College, Al-Qasim Green University

Abstract

A factorial experiment was carried out according to randomized complete block design with three replications in Babylon governorate in two sites (Al-Basira and Al-Nakhaila) during the autumn season 2017 to study the response of three potato varieties (Rivera, Arizonaand Burren) to 4 treatments of foliar fertilization. The foliar treatments were control, 10 ml.l^{-1} of high potash (NPK, 0-5-30), 10 ml.l^{-1} of nutrient solution (nitrogen 7%, phosphorus 5%, potassium 7%, magnesium 0.5%, potassium-humate 0.5% and micro elements) and half the quantity of both fertilizers. The spraying was twice at 45 days of planting (when tubers were formed) and 14 days after the 1st spraying (when tubers were enlarged). The results were summarized as follows: Burren cultivar gave the highest plant height (63.99) cm, leaf number (55.7), leaf area (4955) cm^2, chlorophyll (55.7) SPAD and leaf potassium percentage 2.01%. Spraying of high potash fertilizer was superior in plant length (61.85) cm, number of leaves (57.2), leaf area (5011) cm^2, chlorophyll (57.2) SPAD and leaf potassium percentage (2.07%). Al-Basira local was superior in plant leaf number (52.3), leaf area (5052 cm^2) and chlorophyll (52.3SPAD). The interaction between the varieties and the fertilization was significant in the percentage of plant dry matter.

Keywords: potato varieties, foliar fertilizers, vegetative growth.

[1] Part of M.Sc. thesis of the second others.

تأثير التسميد الورقي في نمو بعض اصناف البطاطا [2]

محمد يوسف مرهج[*] علي حسين جاسم[**]
[*,]كلية الزراعة / جامعة القاسم الخضراء**

الخلاصة :

نفّذت تجربة عاملية وفق تصميم القطاعات العشوائية الكاملة بثلاثة مكررات في محافظة بابل بموقعين (L1 و L2) خلال الموسم الخريفي 2017-2018 ، لدراسة استجابة ثلاثة اصناف بطاطا (ريفيرا و ارزونا و بورين) لأربع معاملات رش بالاسمدة الورقية هي مقارنة ، رش سماد عالي البوتاس (N-P-K، 0-5-30) ، المحلول المغذي (N 7% و 5p% و K 7% و Mg 0.5% و K-humate 0.5% و العناصر الصغرى) و رش نصف الكمية من كلا السمادين . كان الرش لمرتين: بعد 45 يوماً من الزراعة (مرحلة تكوين الدرنات) وبعدها بـ 14 يوماً (مرحلة اتساع الدرنات). و بينت النتائج تفوق الصنف بورين بأعلى حاصل للنبات الواحد والحاصل التسويقي والحاصل الكلي بلغ 469.1 غم نبات$^{-1}$ و21.63 طن هـ$^{-1}$ و 22.59 طن هـ$^{-1}$ بالتتابع . كما حقق سماد عالي البوتاس أعلى حاصل للنبات الواحد و الحاصل التسويقي وحاصل كلي بلغ 440.4 غم نبات$^{-1}$ و 20.81 طن هـ$^{-1}$ و 21.84 طن ه$^{-1}$ بالتتابع .

كلمات مفتاحية : أصناف بطاطا ، تسميد ورقي ، سماد عالي البوتاسز

البحث مستل من رسالة ماجستير للباحث الاول[1].

Introduction

Potato (*Solanum tuberosum* L.) is one of the most food plants in the world, which form between 75-90% of the world's daily food. Potato tubers are rich in amino acids. They contain 18 amino acids out of 20 which giving good nutritional value (Muthoni and Nyamongo, 2009). The area of potato cultivation in Iraq was 7971hectares in 2016, with a production of 190702 tons (23.924t.he^{-1}), [4]. The selection of varieties is an important factor which control the growth and its influenced by prevailing environmental conditions and thus its genetic expression [11]. In order to increase production, the horizontal and vertical expansion of the cultivated area was required by selection of the best varieties suitable for the environmental conditions of the area [15] and the best way of fertilization. Potato is a heavy nutrient requiring crop because of their bulk yields within a short time and having shallow root systems [5]. The addition of chemical fertilizer to the soil constitutes a high proportion of production costs and the extravagance in addition to the major damage to the environment and human [16]. Foliar fertilization is important for the additional processing of plant nutrients [8], especially in the stage of composition and expansion of potato tubers because it is the critical period for the plant's need for nutrients. As tubers become the largest, it need more nutrients and foliar fertilization was the best compared to soil fertilization during this period [14]. Because of that the experiment was conducted to study the response of three potato varieties to supplementary foliar fertilization in south Babylon.

Materials and methods

The experiment was carried out during the autumn season 2017in two locations of south Babylon: Al-Basira and Al-Nekheila (table 1), with a distance of 35 km between the fields. Soil fertilizer (DAP) at the rate of 400 kg per hectare was uniformly added for each field, then the field was divided into three replicates each containing 12 experimental units (containing 4 ridges 75 cm apart and 2.5 m long), leaving 1 m between each experimental unit. Seed tubers of the three potato varieties (Rivera, Arizona and Burren), which were locally produced, brought from one private cooling stores and planted on 15/9/2017 in hills 25 cm apart and 15 cm depth. Spray treatments included control (distilled water), high potash fertilizer (N-P-K 0: 5: 30) at 10 mL l^{-1}, nutrient solution (N 7%, P5%, K 7% , Mg0 5%,potassium humate 0.5% with micro-nutrients) at 10 ml L^{-1} and spraying both fertilizers with a concentration of 5 ml L^{-1} after 45 days of planting (tuber formation) followed by the second one after 14 days (tubering expansion stage). The irrigation was done as needed. Tubers were harvested on 5/1/2018. Data were taken during the growing season included: plant length (cm), leaves number, leaf area (cm^2), chlorophyll in leaves (SPAD), percentage of dry matter and leaf content of nutrients (NPK) were estimated. The data were analyzed statistically using the GENSTAT program, and the averages were compared by the least significant differences ($LSD_{0.05}$).

Table (1): Some physical and chemical characteristics of two locale soil.

Characteristics		Al-nakhala locale	Al-bsaira locale	Units
pH		7.5	7.4	-
EC		3.4	2.2	dS.m^{-1}
N (available)		31.30	22.73	mg.kg^{-1}
P (available)		7.11	6.14	mg.kg^{-1}
K (available)		91	107	mg.kg^{-1}
0rganic matter		1.2	1.1	%
Soil separators	sand	350	480	g.kg^{-1}
	silt	530	450	g.kg^{-1}
	clay	120	70	g.kg^{-1}
Soil texture		Medium loam	Medium loam	

Results and discussion

Plant length (cm)

The results of Table (2) showed that there were significant differences in the average length of the plant. Burren variety gave the highest plant length (64.59 and 68.38) cm, with an increase rate of 15.50 and 17.11% for both locals respectively. This due to the genetic variation between varieties that control the responsible for vegetative growth characteristics, or due to the differences in the content of hormones. Table (2) also showed that spraying treatments caused a significant effect on plant length compared to control treatment. High potash fertilizer gave the highest plant length (62.85 and 60.85 cm), while the control gave the lowest plant length (54.99 and 53.61 cm). The percentage of increase was 14.3 and 13.5%, respectively for both locals. The reason was due to the fertilizer spraying which provided the basic nutrients to the plant and thus achieved better growth because plant length is positively correlated with the addition of nitrogen and potash fertilizer [10]. These results were agreed with [7 and 14]. The interaction between the varieties and fertilization caused a significant effect on plant height. Burrenx high potash gave thehighest plant length (68.14 cm) compared to Arizona x controlfor both site.

Table (2): Effect of varieties spraying treatments and locale on plant height (cm) of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	53.88	52.54	58.56	54.99
F_1	60.96	58.57	69.03	62.85
F_2	56.68	58.47	64.58	59.91
F_3	58.63	57.12	63.20	59.65
Mean	57.54	56.93	63.59	
$LSD_{0.05}$	Variety=0.855 Foliar Fert= 0.987 Interaction=1.710			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	52.58	50.21	58.06	53.62
F_1	58.37	56.93	67.26	60.85
F_2	54.79	53.83	63.26	57.29
F_3	56.74	55.54	64.95	59.08
Mean	55.62	54.13	63.38	
$LSD_{0.05}$	Variety=0.645 Foliar Fert= 0.744 Interaction= 1.289			

Plant leaf number

Table (3) showed that varieties caused significant differences in the number of leaves per plant. Burrengave the highest average number of leaves (55, 73 and 57.46) leaves per plant, compared to Rivera, with an increase of 20.4 and 11.5% for both sites respectively. This is due to the difference in genetic factors [13].The spraying treatments caused a significant increases in the number of plant leaves compared to the control treatment. Spraying high potash fertilizer significantly was higher than all other spray treatments by giving the highest number of leaves (59.6 and 54.7) for both sites respectively, compared to control treatment which gave 43.4 and 46.0 leaves. This is due to the fact that fertilization

spray has improved plant growth and high potash fertilizer, was superior by providing K to plant. K element enters into many important enzymes, and plays an important role in the activation of enzymes [18] and the representation of some proteins that accompany the representation of carbohydrates, which increases plant length (Table 2) and thus increase the number of leaves [6].

These results were agreed with [7 and 9]. The site had a significant effect on the number of leaves, and the local (L1) achieved the highest average of 52.3. The interaction between the varieties and the spraying treatments and the location showed a significant effect on plant leaf number, and Burren × L1x high potash) achieved the highest average (65.67 cm).

Leaf area (cm^2)

Table (4) showed that varieties caused a significant differences in leaf area (cm^2). Burren achieved the highest leaf area (5585 and 4325 cm^2) compared with Rivera variety in both sites. This is due to the genetic differences [19], which was reflected in plant height (Table 2) and in the average number of leaves (Table 3) and thus leaf area. Spraying fertilizer treatment had a significant effect on leaf area compared to control treatment. Spraying high potash fertilizer achieved the highest leaf area (5756 and 4266 cm^2) for both sites respectively, while the control treatment achieved the least leaf area (4193 and 3916 cm^2), with an increase of 37.27% and 8.93%.

Table (3): Effect of varieties spraying treatments and locale on plant leaves number of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	45.583	43.530	48.794	45.969
F_1	52.965	52.785	58.434	54.728
F_2	48.443	48.472	53.698	50.204
F_3	50.231	48.946	55.066	51.414
Mean	49.305	48.433	53.998	
$LSD_{0.05}$	Variety=0.811 Foliar Fert = 0.937 Interaction= 1.622			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	45.583	43.530	48.794	45.969
F_1	52.965	52.785	58.434	54.728
F_2	48.443	48.472	53.698	50.204
F_3	50.231	48.946	55.066	51.414
Mean	49.305	48.433	53.998	
$LSD_{0.05}$	Variety=0.4726 Foliar Fert= 0.5457 Interaction= 0.9452			

This may be due to the role of potassium in the biological processes within the plant, which increases the efficiency of photosynthesis and increase the metabolic processes within the cells by of the role of K in the activation of many enzymes responsible for these processes, which reflected positively in the increase in division of cells and increase the surface area.

Table (4): Effect of varieties spraying treatments and locale on leaf area (cm^2) of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	3984	4080	4516	4193
F_1	5286	5601	6382	5756
F_2	4536	5023	5606	5055
F_3	4763	5014	5835	5204
Mean	4642	4929	5585	
$LSD_{0.05}$	Variety=78.4 Foliar Fert = 90.5 Interaction=156.8			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	3762	3856	4131	3916
F_1	4215	4148	4434	4266
F_2	4195	4095	4404	4231
F_3	4165	4092	4331	4196
Mean	3762	3856	4325	
$LSD_{0.05}$	Variety=110.8 Foliar Fert =127.9 Interaction= N.S			

These results were agreed with [7]. Who stated that Potassium is essential to obtain maximum leaf extension and stem elongation. This is due to the fact that spraying with nutrient solution that helped to improve plant vegetative growth by increasing plant length and number of leaves (Table 2 and 3) and thus increased the leaf area or containing nutrient solution like Zn which is important in tryptophan synthesis and then formation of IAA. The site had a significant effect on leaf area and the first site gave highest average of (5052) cm^2.

Chlorophyll content (SPAD)

Table (5) showed that varieties had significant differences on chlorophyll content (SPAD). Burren variety gave the highest average57.46 and 53.99 SPAD in first and second sites. This is due to the differences in genetic [2]. On the other hand, spraying fertilizer treatments had a significant effect on chlorophyll content (SPAD) compared to the control treatment. High potash fertilizer spraying treatment was superior significantly compared to all other spraying parameters and gave the highest chlorophyll content (59.57 and 54.72) SPAD compared to control (43.39 and 45.96) with an increase of 37.28 and 19.05% for both sites respectively. This is due to the role of potassium in controlling the ionic balance and the role of the minor elements added including Mg, which is the centre of the chlorophyll molecule. K^+ also plays a role in activating the enzymes responsible for the assimilation and construction of chlorophyll. These results were agreed with [7]. The site had a significant effect on chlorophyll and the first location achieving the highest average of 52.3 compared to 50.57 SPAD in the second site). The interaction between the varieties and spraying treatments had a significant effect on chlorophyll content, and Burrenx high-potash fertilizer gave the highest of65.67 and 58.43 SPAD.

Table (5): Effect of varieties spraying treatments and locale on chlorophyll (SPAD) of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	77.01	69.89	79.81	75.57
F_1	82.72	77.89	85.56	82.06
F_2	78.73	72.79	81.28	77.60
F_3	81.02	74.11	82.47	79.20
Mean	79.87	73.67	82.28	
$LSD_{0.05}$	Variety=0.580 Foliar Fert =0.670 Interaction=1.160			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	70.43	67.26	75.39	71.03
F_1	81.83	81.56	90.28	84.56
F_2	74.85	74.89	82.97	77.57
F_3	77.61	75.63	85.08	79.44
Mean	76.18	74.83	83.43	
$LSD_{0.05}$	Variety=0.730 Foliar Fert =0.843 Interaction=1.460			

N% in leaves

Table (6) indicate that variety had no significant effect on leaves nitrogen percentage, but fertilizer spraying treatments caused a significant effect on the percentage of nitrogen in the leaves compared to control treatment. Sprayingnutrient fertilizer treatment achieved the highest percentage of nitrogen in the leaves (2.32 and 2.30%) campared to control (1.89 and 1.94 %). This is due to the important roles of the elements in the various biological processes and the reflection on the increase of the plant efficiency and its ability to absorb nitrogen, which reflected in rise of leaf nitrogen percentage. In addition to the active contribution of potassium, whether alone or in combination with other elements in increasing the ability of the plant to benefit from nitrogen and increase its absorption rate [3]. The interaction between the site, varieties and spray treatments had a significant effect on the percentage of nitrogen in the leaves, and the first site × Arizona x nutrient solutionfertilizer gave the highest average of 2.38%.

P% in leaves

Table (7) indicates that the varieties had no significant effect on p% in

leaves, but fertilizer spraying treatments caused a significant effect on p% in the leaves compared to control treatment. Spraying high potash fertilizer treatment achieved the highest percentage of phosphorus in the leaves (0.53%) in first site but nutrient solution achieved the highest percentage of phosphorus in the leaves (0.51%) in second site compared to control treatments (0.46 and 0.41 %), in both sites respectively. This is due to the direct spraying of the element increases its uptake by the plant tissues, as well as the role of the micro elements present in the nutrient solution, especially Fe in increasing the absorption of phosphorus. The site had a significant effect on the phosphorous percentage in leaves, and the first site gave the highest average reached 0.51 compared to 0.47%.

Table (6): Effect of varieties spraying treatments and locale on leaf N% of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	1.870	1.890	1.930	1.896
F_1	2.253	2.303	2.273	2.284
F_2	2.276	2.380	2.340	2.324
F_3	2.223	2.283	2.246	2.251
Mean	2.155	2.214	2.197	
$LSD_{0.05}$	Variety=0.025 Foliar Fert = 0.02908 Interaction0.05037			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	1.956	1.956	1.926	1.946
F_1	2.243	2.116	2.210	2.190
F_2	2.300	2.286	2.323	2.303
F_3	2.203	2.250	2.286	2.246
Mean	2.175	2.152	2.186	
$LSD_{0.05}$	Variety=N.S Foliar Fert = 0.05545 Interaction=1.460			

Table (7): Effect of varieties spraying treatments and locale on leaf P% of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	0.443	0.476	0.460	0.460
F_1	0.513	0.530	0.530	0.524
F_2	0.520	0.546	0.536	0.534
F_3	0.516	0.526	0.523	0.522
Mean	0.498	0.520	0.512	
$LSD_{0.05}$	Variety=0.00998 Foliar Fert = 0.01152 Interaction= N.S			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	0.403	0.413	0.407	0.408
F_1	0.473	0.510	0.483	0.489
F_2	0.507	0.513	0.503	0.508
F_3	0.480	0.487	0.493	0.487
Mean	0.467	0.482	0.472	
$LSD_{0.05}$	Variety=N.S Foliar Fert=0.0682 Interaction= N.S			

K% in leaves

Table (8) showed that varieties had a significant difference in the percentage of K% in the leaves where Burren variety gave higher K% in the leaves reached to 1.99 and 2.04% in both sites respectively compared to the other two varieties. This is due to the nature of the variety growth by increasing the capacity of absorption as well as the differences of the varieties genotypes and its suitability to the environmental conditions.Spraying treatments caused a significant effect on K% in the leaves compared to control treatment. Spraying of high potash fertilizergave the highest percentage of K in the leaves (2.12 and 2.03%) in both sites compared to control. This is due to the fact that fertilizer spraying provided quantities of potash ready for absorption, which led to increase its concentration in leaves [12]. The interactionsbetween the varieties , spraying treatments and the location had a significant effect on the percentage of potassium in the leaves (%). The combination of (Burren x nutrient solution xL1) achieved the highest potassium percentage (2.195%).

Conclusion

We concluded that Burrenwas superior in most vegetative traits compared to Rivera and Arizona varieties for both sites. Spraying of high-potash fertilizer at a concentration of 10 ml / L contributed to the improvement of vegetative characteristics of both sites. Both Burren and high potash fertilizers (10 mL / L) achieved the best results in most studied traits in both sites.

Table (8): Effect of varieties spraying treatments and locale on leaf K% of two local.

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	1.6800	1.7100	1.7767	1.7222
F_1	2.0933	2.1260	2.1300	2.1164
F_2	2.0100	1.9500	2.0733	2.0111
F_3	1.9667	2.0167	1.9967	1.9933
Mean	1.9375	1.9507	1.9942	
$LSD_{0.05}$	Variety=0.02133 Foliar Fert=0.02463 Interaction= 0.04266			

Variety / Foliar Fert.	V_1	V_2	V_3	mean
F_0	1.6530	1.8437	1.8417	1.7795
F_1	1.9893	1.9090	2.1953	2.0312
F_2	2.0307	1.9714	2.0345	2.0122
F_3	1.8409	1.9828	2.0816	1.9684
Mean	1.8785	1.9267	2.0383	
$LSD_{0.05}$	Variety=0.04230 Foliar Fert=0.04884 Interaction=0.08459			

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